

Human Energy Diary Studies with Personalized Feedback: A Proof of Concept with formr

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Abstract: While the current pandemic amplifies the trend of highly self-responsible and flexible work, many employees still struggle addressing the resulting self-management challenges like balancing strain and recovery. Maintaining health of employees is a major concern of organizations to remain competitive, but in the context of highly individual work, this can hardly be supported with classical occupational health initiatives. Thus, it is crucial to develop tools that provide individuals with personal insights on their everyday work and help them determine applicable health behaviors. Towards this goal, we report on our design and implementation of diary studies with personalized feedback about persons' energetic wellbeing. Whereas such studies enable to research phenomena at the collective level, they can additionally act as intervention at the individual level. This is especially relevant to 1) provide a motivational incentive for continued participation and 2) raise awareness about recent topics in occupational health and promote healthy behaviors, while advancing research concerns. We provide insights from several studies regarding the generated feedback, the perception of the participants and IT-related improvement potentials. Hopefully, this will inspire further research that takes advantage of the win-win situation conducting studies, which simultaneously provide participants with individual insights.


1 INTRODUCTION


In the past decades, working conditions shifted more and more towards complex and knowledge-intensive tasks, increased expectations for flexibility, and high speed (Green and McIntosh, 2001; Parent-Thirion et al., 2017; Biletta et al., 2021). Thus, managing balance in life became more challenging for individuals (Green and McIntosh, 2001; Barber and Jenkins, 2014). In this context, the so-called *human energy* plays a major role. Quinn et al. (Quinn et al., 2012) describe human energy as an organizational resource that increases employees' ability to act by motivating them to do their work and achieve their goals. Human energy is an umbrella term that comprises physical aspects, like the

available glucose in the blood enabling humans to act, and subjective aspects, like the degree of feeling alive. Quinn et al. call these two components physical energy and energetic activation and present an integrated model of human energy at work that can be seen in Figure 1. Yet, research provides only scattered indications of which factors influence especially the subjective component of energetic activation and how an employee can proactively improve energy management on an individual level (i.e. energy self-management). Although prior research investigated the fields of job design (Grant and Parker, 2009), leaderships (Inceoglu et al., 2018; Skakon et al., 2010) and interventions (Tetrick and Winslow, 2015) in order to foster employee wellbeing, addressing self-management challenges via digital solutions has

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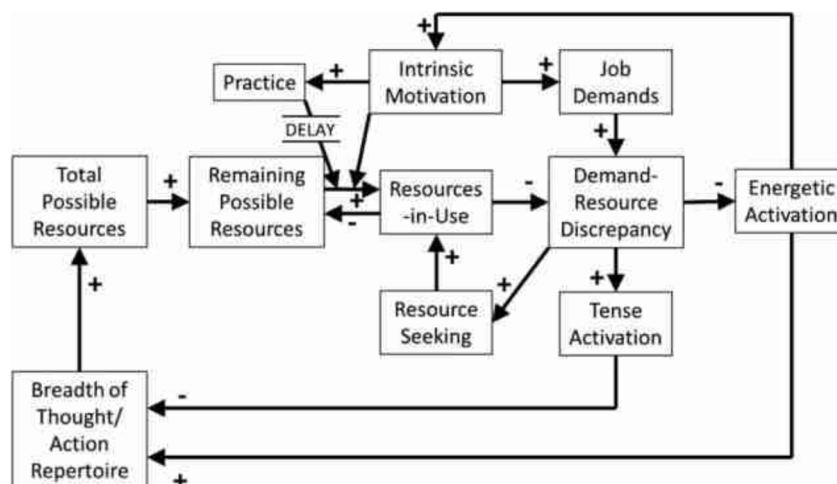


Figure 1: The integrated model of human energy over time in a work context (Quinn et al., 2012), which is a theoretical basis of the presented studies with feedback on human energy.

not yet received much attention (Li and Vogel, 2021). Self-management is key to find and improve the own individual way to perform (Drucker, 2005). It means controlling the own actions in a way that prefers behaviors with consequences desirable in the longer-term over short-term outcomes (Manz and Sims, 1980). Self-management skills are essential for work characterized by high degrees of freedom (Kleinmann and König, 2018). In order to manage oneself, several strategies can be used. Self-observation, where a person systematically gathers data about the own behaviour (Manz and Sims, 1980), is an exemplary strategy that is especially relevant in our context. Indeed, designing and implementing IT-based tools that support employees in the collection and analysis of data relevant for self-reflection is a promising avenue of research (Choe et al., 2017; Rapp and Cena, 2014; Fallon et al., 2018). Specifically for human energy, there is yet no technical support assisting individuals in identifying how different factors like micro-breaks (Kim et al., 2018) influence their energy level. Determining the influencing factors that are particularly relevant within the own working day would be highly valuable in order to proactively increase the own energy level or prevent a decrease.

Diary studies help to regularly gather data about peoples' situation, especially if there is no established automatic measurement instrument like sensors for the targeted phenomena yet. They provide gaining insights over a certain period of time by requiring the participants to submit protocols of their activities independently and frequently (Janssens et al., 2018). The character of a diary study enables combining research with the provision of early and individual feedback to the participants of the studies, even

before the detailed scientific analyses take place that focus more on generalizable results. Overall, diary studies are very reasonable to keep track of dynamics in experiences of and between employees in organizations (Ohly et al., 2010). As diary studies can require much time from the participants depending on how frequently and deeply they are asked to assess their situation, providing individual feedback may raise the intrinsic motivation for regular participation (Vries et al., 2021). With this, the participants expect and receive insights, they are likely interested in. Through generating personalized feedback on human energy during work days, we furthermore strive to empower employees to better understand their energy and improve their management in such a way that enables overload prevention and lasting work pleasure. This would create added value for the individual as well as the organization, which in addition might lead to a better feasibility of implementing diary studies for research purposes in organizational contexts.

However, the design and implementation of IT-supported diary studies with personalized feedback remain challenging in terms of the technical infrastructure required and the existing sample cases described in sufficient detail to learn from. In addition, there is also a lack of research how participants perceive personalized feedback in diary studies. Against this gap, we report on the design, implementation and execution of our IT-supported diary studies on human energy using the established tool *formr*. Our results thus can inform the design and implementation of future IT-supported diary studies that emphasize personalized feedback.

2 RELATED WORK

In this section, we provide information on related studies and tools starting with ambulatory assessment studies more generally and proceeding with electronic diary studies with feedback and the digital tool we used for our diary studies.

2.1 Ecological Momentary Assessment and Intervention Studies

A term commonly used in diary research is ecological momentary assessment (EMA), which includes diverse ambulatory assessment methods (Janssens et al., 2018). EMA refers to methods involving repeated sampling of subjects' current behaviors and experiences in real time (= "momentary") in the natural environment (= "ecological"). Thus, EMA comprises not only methods using diaries, but also such using e.g. physiological sensors (Shiffman et al., 2008).

Existing electronic EMA studies are often focused towards researching interesting phenomena such as (clinical) symptoms, behaviors or perceptions and their interplay. For example, there are numerous studies that focus on understanding basic psychological need fulfillment at the workplace, as summarized by Coxen et al. (2021) in their analysis on 20 diary studies. Giving participants feedback is not at the heart of such studies. Rather, data is collected for understanding and gaining scientific knowledge about the phenomenon under consideration. Vries et al. (2021) focus in their review on smartphone-based EMA studies on wellbeing and explicitly recommend providing feedback to the subjects at the end of the study in order to motivate them for continued participation. Even though about half of the analyzed 53 smartphone-based EMA studies additionally integrate passive sensor data, nearly all studies also use the collected data for their research analyses only. The review mentions just one exemplary study, in which participants got feedback in form of personalized graphs about their happiness. We will look at this study in the next section, as its approach is quite similar to what we propose.

In addition to the more insight-oriented studies described so far, there are also intervention-oriented studies. In the mobile context, such studies aim at delivering just-in-time prompts as treatments, as indicated in a review on 27 ecological momentary intervention (EMI) studies with mobile technology support (Heron and Smyth, 2010). This sort of feedback often is directive in its nature and presented e.g. in the form of small textual messages.

Alternatively, interventions are offered by questions, conversational interaction, or multimedia content as described in a review study on 64 EMI studies by Balaskas et al. (2021). Four of the analyzed studies actually provided participants feedback in form of graphical data visualizations of past entries. These studies are addressed in the next section together with others including visual feedback. However, the feedback provided seems to be a by-product of the actual goal to deliver and research momentary interventions that are used as treatments and is often just roughly mentioned. In contrast to EMI designs, we propose to utilize the integration of rich visualizations of participant data for reflective purposes and higher participation motivation even for studies that have mainly an assessment character and do not necessarily aim at intervening in opportune moments.

To summarize, while previous work mostly focused on insight-oriented or intervention-oriented studies, we specifically focus on a study type between these that enables assessments for research purposes, but includes a reflective benefit for the participants providing rich and personalized feedback. Besides the benefit for participants, this approach also provides the perfect basis to evolve an insight-oriented study later into an intervention-oriented study using the feedback as an intervention for reflection or adding other interventions. This would also promote the connection of EMA and EMI techniques that remained largely separate, but would enable better tailoring and delivery of interventions (Heron and Smyth, 2010). In the next section, we analyse the few works that are closer to our approach by providing reflective visual feedback on the collected data.

2.2 Electronic Diary Studies with Feedback Generation

According to Narciss (Narciss, 2006), *feedback* is an information given to a person during or after a process in order to have a regulating effect on that process. Zannella et al. (Zannella et al., 2020) state a beneficial effect caused by feedback, if used cautiously. They argue that providing participants with personalized feedback may not be generally feasible, especially where results can be sensitive or easily misinterpreted as a wrong psychological diagnosis. Thus, they suggest carefully deciding which captured data is considered for feedback and how it is presented to decrease the risk of misconstruing.

Unfortunately, many research documentations about diary studies with feedback generation neither describe the design nor the impact of the generated

feedback. The authors then just mention that feedback was provided for the participants, but do not explain more on that (Rentzsch et al., 2021; Richter and Hunecke, 2021; Arslan et al., 2019a; Arslan et al., 2019b; Holzleitner et al., 2017; Pusch et al., 2020; Depp et al., 2015; Kazemi et al., 2019).

Few works at least shortly describe the feedback they generated for their participants. For example, Burns et al. (2011) provided participants visual feedback related to depression, e.g. a graph showing the frequency of the locations they were at together with their average reported mood in each location. Kroska et al. (2020) developed an application for assessment and intervention in their study that can visualize data collected regarding mood and activity. Participants can access graphs e.g. on their depressive symptoms, perceived stress symptoms, or certain behavior over three days. Advanced visual feedback on health and wellbeing was provided to participants in the study by van der Krieke et al. (2017). Besides some rather basic graphs like frequency of certain activities ranked by perceived pleasantness, also personal networks showing concurrent and dynamic relationships between mood, health behaviors, and emotions over time were presented to participants. While the aforementioned studies can well inspire the design of feedback to be generated for the participants, they all lack describing their technical infrastructure and corresponding study design in sufficient detail for reuse. Researchers conducting EMA studies often use applications, which were specifically developed for their research and thus the development costs a lot of time and money (Vries et al., 2021). For studies with feedback generation, it is even more important to build on an existing infrastructure to reduce complexity of implementation. Non-commercial tools that provide functionality for conducting a diary study as well as generating comprehensive personalized feedback while fulfilling research demands (e.g., reproducibility, traceability, privacy guaranteed or extensibility), are still rarely found. Furthermore, non-commercial software is often poorly maintained due to limited resources (Arslan et al., 2019c).

Arslan et al. (2019c) developed a study framework and an open-source software tool that tackles this gap, namely formr (see next section for more information). They describe in their paper three case studies with automatized feedback illustrating the capabilities of their tool. One exemplary diary study with personalized feedback aimed to investigate daily habits and sexuality of women over a period of 70 days. The participants received various personalized feedback at the end of this study. In

addition to personality feedback, the study provided them with visualizations of the variation of their mood, desire and stress level during their menstrual cycle. The participants could even investigate several visualized correlations between the quality of their sleep and mood level and their alcohol consumption on the previous day. Additionally, an interactive display provided the participants the possibility to retrace their mood level over time and investigate their answers from a specific day. Moreover, the participants were also provided with a spider diagram showing the distribution of activities in portions during the week and the weekend.

Conducting a study with formr that uses diverse of its features, is still challenging due to the complexity of possibilities and the still rather short information on exemplary cases. With this article, we contribute an exemplary case with descriptions of study designs, implementation choices, participant perceptions, technical challenges, and learnings from our study on human energy, specifically focusing on combining EMA and personalized feedback. We provide with this a proof of concept for future studies and hope to reduce barriers other researchers may face when conducting a similar study.

2.3 formr – A Tool for Diary Studies

Arslan et al. (2019c) developed formr, a study framework and an open-source software tool supporting researchers in conducting a wide range of studies (i.e., from simple surveys to even more intricate research). Thereby, it allows to automatically send email or SMS notifications to registered participants. Researchers can thus determine a specific time schedule formr follows. The notifications embody an external trigger to remind and motivate participants to do their self-assessments. Furthermore, formr supports the coding language R to execute more complex tasks like generating personalized feedback. Through coding in R, a wide range of different visualizations can be created for the feedback. For instance, a participant's data can be shown in a table, pie chart, bar chart, line graph or radar chart.

Overall, the formr framework consists of three main elements: 1) the survey framework, 2) the study framework (aka "run") and 3) the R package. In the survey, researchers can define questions and to correspondingly gather data from participants. The "run" of provides researchers the possibility to actively manage and drive the survey (i.e., researchers can manage access to a study, define when which questions are answered by whom, send

emails or text messages to remind or invite the participants and provide feedback to the users). Whereas those two main components of formr are coded in PHP, the third one is the utility R package and thus independent from the other PHP code. This should ensure common operations (like cleaning and aggregating data or setting timeouts for analyzing purposes) becoming easier to implement for the researchers. The R package is connected to the PHP software via a RESTful API allowing researchers to use many familiar packages directly in formr (e.g., for displaying graphical feedback to the users). Overall, those features seem to perfectly fit the requirements of performing longitudinal studies and thus also diary studies. That is, data can be gathered from participants by creating surveys, the execution of those surveys can be maintained in the runs (e.g., by reminding inactive users to continue participating) and the gathered data can be precisely analyzed afterwards using the R packages.

3 STUDY DESIGNS

Based on positive response of participants in first studies, we conducted three diary studies on human energy over the last three years where we combined researching human energy in terms of energetic activation and its influencing factors with developing a flexible study procedure and valuable feedback for the participants of the studies. In this, we iteratively improved the personalized feedback provided to the participants and added more and more complexity to it in order to maximize knowledge gain. All studies had a similar procedure design, but with different frequencies of requested self-assessments per day and different influencing factors and corresponding scales. While our procedure design could function as a blueprint for future studies, the things we changed from study to study are the key elements to adjust for each new context, in which a diary study based on our design shall be conducted. The key concept and influencing factors depend on the objective of the research and on the demands of the studied domain or organization. Furthermore, an essential lesson learnt from conducting our studies is that feedback on influencing factors is relevant mainly, if the assessed factors are actionable in terms of a possibility for the participants to change the manifestation of the factor. Thus, we shifted the items assessed in the last study more to behavioral strategies. From a research point of view, the frequencies of assessments should be as high as possible to collect a large data set for subsequent analyses. However, in practice the

frequencies of self-assessments and number of items used for assessment strongly rely on the feasibility in terms of the time needed by the participants to answer the surveys. This is especially true in case of assessments during the work day as in our study designs. In the following, the commonalities of the study designs are described first and then illustrated by the exemplary procedure of our latest study. Each design consisted of:

- An initial questionnaire for contact and demographic data
- Individual survey days including only work days
- A number of surveys per day with a designated e-mail reminder
- A short energy-related measurement at each measurement point for the momentary state
- Scales for retrospective assessments of different influencing factors, e.g. sleep quality, work characteristics, recovery activities, and used work strategies
- Feedback generated from the individual data

Two of our three studies included ten survey days with up to four surveys per day at meaningful time points for work and leisure – in the morning, noon, afternoon, and evening. In one study considering an average working day with eight hours, there were even up to eight surveys a day to complete, but just for three days of participation then and with the same questionnaire for all diaries. In the last studies, a final questionnaire asked for the participants' perception of the study and generated feedback. The rest of this section describes the so-called formr run (cf. Section 2.3) of our latest study in order to illustrate with a concrete example, how the procedure of further studies can look like. The procedure is as follows:

When entering the study link, the questionnaire shown first is for meta data like the email address for further invitations, the favored starting day, typical start time of the working day, and some demographic data. Furthermore, the participants are asked to estimate how their energy might develop throughout a typical day. For this, we used a pictorial scale of human energy (Lambusch et al., 2020; Weigelt et al., 2022) as shown in Figure 2, because it is more natural estimating a status with just one visual item.

The main study starts with an invitation link to the first diary entry after a waiting time that lasts until the chosen starting day one hour after the participant's individual work begin. Every diary contained a short energy-related measurement comprising the pictorial scale of human energy and a few items of verbal scales.



Figure 2: Pictorial scale of human energy with seven response options ranging from a depleted to a fully-charged battery according to Weigelt et al., 2022.

As energetic activation represents the subjective experience of human energy, it includes all facets of experiencing the presence or absence of energy, e.g. vitality or zest, fatigue or exhaustion. With the diversity of focal aspects of the phenomenon, there are many common instruments that can be used to measure sub-concepts of human energy in terms of energetic activation. In order to keep the diaries as short as possible, we had to decide for few focal aspects to measure. We chose to use three items of the vigor-subscale of POMS (Albani et al., 2005). In earlier studies we used Ryan and Frederick's subjective vitality scale as adapted by Schmitt et al. (Schmitt et al., 2017). Furthermore, we used three items of the tension-subscale of POMS (Wyrwich and Yu, 2011) for every diary in this study. The morning diary, to which the mentioned invitation link leads, complements the energy measurement with questions about sleep, including e.g. the Insomnia Severity Index (Bastien, 2001) and the day so far, e.g. morning reattachment (Sonntag and Kühnel, 2016), and items for planning and goal setting of the German version of the revised self-leadership questionnaire (Andreßen and Konradt, 2007). The run waits 90 minutes for the participant to click the invitation link and complete this diary entry and skips it in case the participant doesn't click the link. In any case the next module is to wait until the individually chosen lunch time, where the next invitation email with a link to the noon diary is sent. In the noon diary questions about e.g. job crafting (Lopper et al., 2020) complement the energy measurement. As this entry shall be completed after lunch and the invitation is sent at the given lunch time, we wait a bit longer here for the participant to complete the diary entry, namely 120 minutes, before this diary is skipped. The afternoon diary is always sent at 4 pm with a waiting time of 90 minutes and the evening diary at 7 pm with a waiting time until 11:59 pm before the entry is skipped. In the afternoon questions are posed about e.g. autonomy (Stegmann et al., 2010), elective selection (Schmitt et al., 2012) and micro-breaks (Kim et al., 2018). while in the evening we ask for concepts like work-life-balance (Syrek et al., 2011) and progress through supplemental work (Weigelt and Syrek, 2017). The described daily procedure starting with a morning diary and ending with an evening diary is a

loop repeated over the course of the study. However, invitations for diary entries are only sent on workdays, not on weekends. Thus, on weekends a waiting time takes effect. After five days of diary entries, the participants of the second group get their intermediate feedback after completing or skipping the evening entry. After ten days of diary entries, all participants get final feedback. After a pause, an invitation to a closing survey is sent to the participants to ask for perception of the study and generated feedback. After completing this survey, the participants have again access to their final feedback via the link. Explanations and exemplary excerpts of the generated feedback are given in the next section on feedback development.

4 DEVELOPMENT OF PERSONALIZED HUMAN ENERGY FEEDBACK

The feedback generated in our studies is intended to empower employees to better understand their energy levels and improve their energy self-management. In this way, we strive to enable overload prevention and promote lasting work pleasure. Instead of providing just general information and tips, the feedback is created personalized from the individual data, e.g. showing a selection of only those influencing factors most relevant for the specific person. The diary study feedback can be seen as a step towards a comprehensive tool helping people to identify those factors, which have a major influence on their individual energy level. To date, our study results already indicate how highly individual energy curves and factors are, supporting our endeavor and the necessity for individual feedback complementing rather general recommendations on energy self-management.

When designing the feedback, we decided that the it should at least include graphs visualizing the development of the participant's energy and representations of how the different scales correlate with it. In our latest feedback design, we additionally provide information on the development of the person's tension as well as on the manifestations of the assessed influencing factors in the everyday work life of the participant. Researchers should carefully elaborate how to visualize which data in advance to a run. For instance, visualizing a user's level of human energy over the time of a day in a line graph seems more suitable than showing its portions in a radar chart. Oppositely, visualizing the manifestations of a

user's different working characteristics in comparison seems to be more reasonable with a radar chart than with a line graph (cf. e.g. Chapter 6.3 in (Skiena, 2017) on chart types). As it is very important to enable the participants to understand what the feedback means, descriptive texts should explain the feedback data and limitations in interpretation. The generated feedback actually addresses critical data in the sense of Zannella et al. (Zannella et al., 2020). Thus, its presentation was carefully elaborated in collaboration with psychologists and cautionary notes were included, e.g. for the influencing factors regarding the difference between correlations and causality. In order to visualize the development of the participant's energy level, two time contexts are important according to existing research: 1) the day level (Golder and Macy, 2011) and 2) the week level (Weigelt et al., 2021). Thus, we provide the participants with a diagram for both levels. For the day level the participants were requested to estimate their mean energy throughout a typical work day with the pictorial scale. In the feedback, we show them their estimation together with their actual mean energy curve over a day (cf. Figure 3). For the week level, we provide the participants a graph with their mean vigor (as one of the manifestations of human energy) of each day during the whole study period (cf. Figure 4). The figures shown in this section are the graphs generated by formr, only texts in the figures are changed in sizes and have been translated from German. A similar curve as in Figure 4 is shown for the participant's tension over the diary study period. Furthermore, we provide information on the daytime with the minimum and maximum mean values for energy and tension, e.g. maximum tension was in the morning with a mean value of 2,2. Next, a series of radar charts illustrates how strongly the possible influencing factors assessed are pronounced in the participant's everyday working life (see Figure 5).

The last diagram of the provided feedback represents a core element for energy self-management, namely the four strongest correlations of the influencing factors with the participant's vigor (cf. Figure 6). In case the participants are interested in reviewing the course of the four strongest correlating factors over the study period in comparison to their energy, it would be possible to create for future studies a graph similar to Figure 4, complementing it with four other line graphs for the correlating factors.

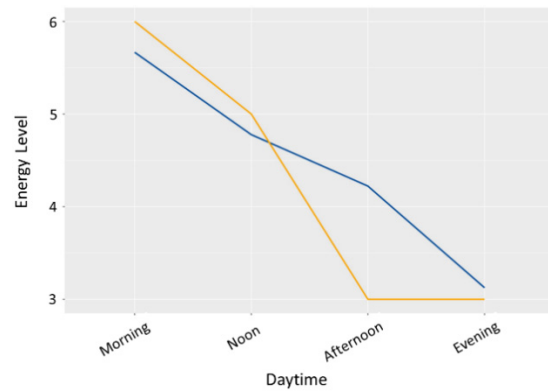


Figure 3: Exemplary formr feedback diagram of a participant's estimated (orange) and actual (blue) mean energy (1 to 7) over the course of a day.

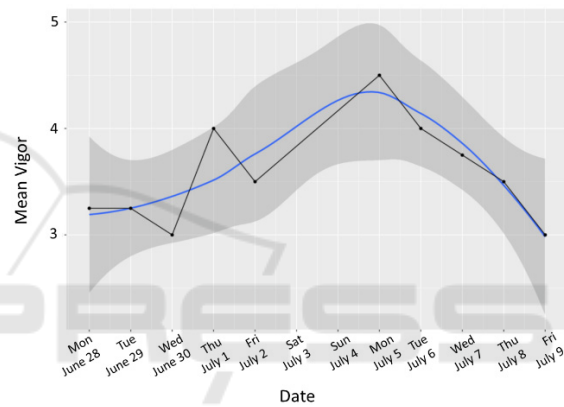


Figure 4: Exemplary formr feedback diagram of individual vigor (1 to 5) over the course of the study. The black graph shows the connected measurement values, whereas the blue graph represents a smoothed curve with an enclosing grey area highlighting the general trend.

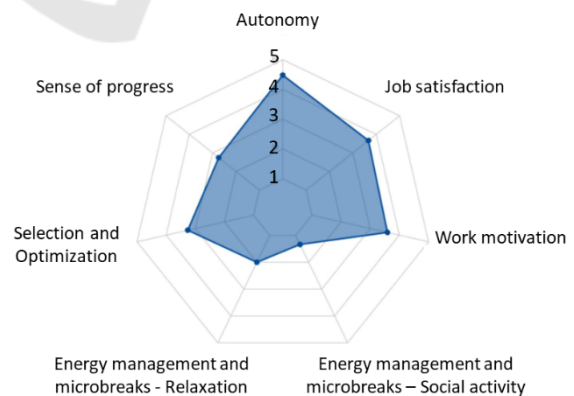


Figure 5: Exemplary formr radar chart for characteristics of a participant's typical day assessed in the noon. It shows the mean assessment value for the factors across all days of participation.

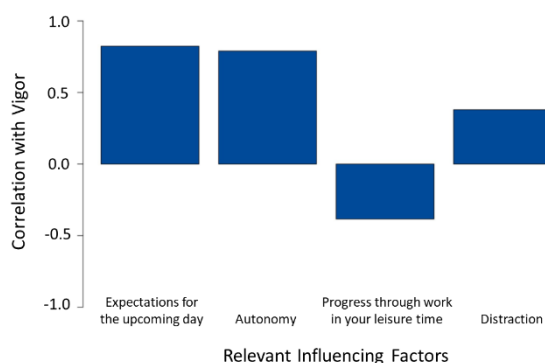


Figure 6: Exemplary formr bar chart displaying the four strongest correlation coefficients of the personal vigor to possible influencing factors.

5 INSIGHTS FROM PROOF OF CONCEPT STUDIES

We conducted a series of diary studies that implemented the analyses and feedback we described on a conceptual level in the previous chapter. Participants were recruited using a convenience sampling strategy, i.e. the invitation was spread through word-of-mouth recommendation and social media (e.g. posted on the platform Xing in a forum about self-management and self-coaching). In sum, 74 persons participated in the studies. In the following, we report on our insights during the studies regarding feedback generation, participants' perceptions and IT-support.

5.1 Observations from Data Analysis

Our study results show how much energy curves and high correlating factors differ on an individual level, which supports the need for personalized feedback in addition to more general recommendations for energy self-management. We illustrate the differences of participants in daily energy in Figure 7. Also for the high correlating factors, we observed that these are largely different between subjects. An explanation for this could be that participants differ in terms of e.g. personality, cognition and also their working conditions. An example for the latter is that postpone or delegation behaviors are not possible if work-related autonomy is rather small.

Furthermore, we were able to derive interesting insights by analyzing the collected data. Since the studies varied slightly and due to space limitations, we are not able to report on all of our findings. A sample finding is e.g. that negative correlations were found for time spent in meetings and subjective

vitality. In regard to the factors influencing human energy, it was e.g. discovered that strength use is positively correlated with vitality. From this it can be deduced tasks should be favored where personal strengths can be applied and that time spent in meetings should be reduced.

5.2 Preliminary Insights on How the Participants Perceived the Study

In the studies we conducted, we collected both qualitative and quantitative feedback from our participants which we summarize below.

Comments to the applied scales. In general, we did not receive negative feedback regarding the understandability (with rare exceptions). However, some new items were suggested by the participants such as work tasks that were assigned at short notice in the evening through mail, SMS or even phone calls and that cause sleep problems or doing sports. A point of criticism was that inapplicable questions could not be omitted.

Feedback to the study execution. Concerning the general study, there were only criticisms about the procedure of the study. According to this, the study should provide more flexibility, i.e. participants wished to determine the time of the questionnaires being sent and to limit questions to a subset they find applicable for their daily life. Also, integration with task calendar, e.g. in Outlook, was suggested in order to not to miss questionnaires. Another idea was to send funny and therefore encouraging messages to the participants during the study in order to avoid the "stiff" character of the questionnaires over time. Furthermore, the issue of time-lag effects was raised, e.g. to measure whether or not there is a drop in performance after overproductive days.

General comments on the impact on personal life. For many of the participants, these questionnaires seemed to have a positive impact on their thoughts. In some cases, it was reported that it stimulated reflection and helped to gain insights into everyday work and how different aspects affect work. In this sense, the studies were able to provide "food for thought". Of course, some more critical remarks occurred too. Predominantly, these were about questions that were felt to be repetitive or irrelevant. Also, the "one-off" nature of the feedback was criticized, i.e. a more incremental feedback was preferred.

Perceived relevance and usefulness of the feedback. We included a final questionnaire at the end of the last two studies to ask for participants' perceptions of the feedback. In one of the studies,

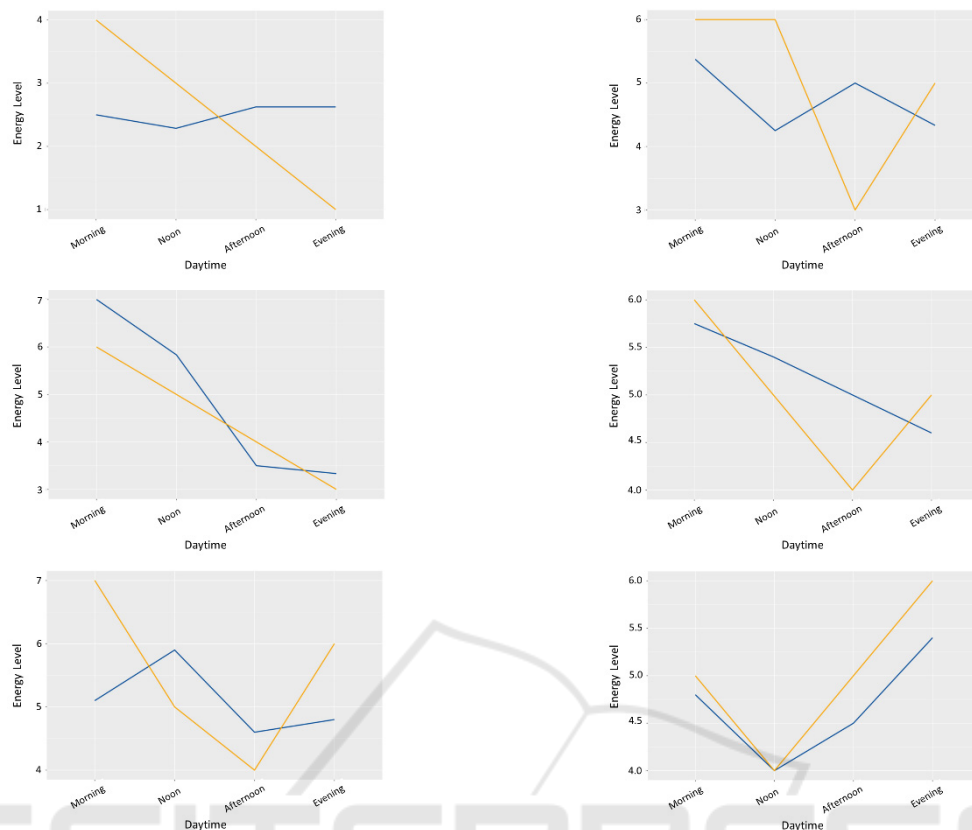


Figure 7: Comparison of energy curves of different participants on the day level. Orange lines represent the participants' estimated energy curve and blue lines the actual energy.

participants ($n=27$) had to specify their agreement on a 5 point Likert scale ranging from disagreement (1) to complete agreement (5). In regard to the proposition that *the feedback is useful for everyday work*, most of the participants answered with 3-4 with approx. 42% for each value. In regard to the assertion that *the time invested in the study is useful*, approx. 68% of the participants highly or even completely agreed to this (4-5). Moreover, more than 60% of the participants answered with 3-5 regarding the question of *being able to integrate the content of the feedback into their everyday work*. Furthermore, *being able to derive personal benefit from the feedback of the study* was highly agreed (4) by approx. 37%. In regard *whether the participant's knowledge could be expanded in the long term with the help of the feedback*, this question was mostly answered with 2 (21.1%) and 3 (52.6%). Finally, in regard to the statements that *new knowledge could be generated by the study* and that *something could be learned through the study*, most participants somewhat or highly agreed (3-4). This is also consistent with the overall average, as the most common response options for the entire final questionnaire were 3 with

33.1% and 4 with 32.3%. In sum, over 60% of the participants responded positively to the study evaluation form.

5.3 Challenges and Learnings regarding the IT-support

Regarding the technical implementation of the study, the most important learning was that timing problems should be handled with caution. There is a so-called "expiry date", which can be set in the settings of each questionnaire. It determines how long a questionnaire can be filled in. However, only when this period is exceeded, the participant can receive the invitation for the next questionnaire. The period between the questionnaire in the morning and at noon, for example, was set to 300 minutes first. However, this did not take into account that often questionnaires do not arrive on time at 7 a.m., but also sometimes later. If this is the case, the "expiry date" overlaps with the invitation time of the following questionnaire and an error occurs where participants get stuck in the run and do not receive any further invitations. The problem could be solved by subtracting 10 minutes

from the expiry date. Such timing problems may be caused due to the computational load of the server that is hosting the study. We currently explore this issue further. Another logical error found was that after entering the last questionnaire of a day, the participants jumped via the rewind module to the invitation on the next morning. However, this only works if the respondent completes the questionnaire on the same day. If this does not happen, the run skips a day. This problem was also solved by implementing an if-statement before the last questionnaire.

6 CONCLUSION AND OUTLOOK

Today's working world can be characterized by increased flexibility and ever growing complexity of products and services in highly dynamic markets. This induces high workloads, constant time-pressure as well as blurring borderlines between different life-domains. For individuals as well as organizations, it can be hard to keep pace. Hence, good self-management capabilities in terms of controlling the own behaviors in a long-term desirable way are of vital importance for promoting productivity as well as sustainable health management. In this direction, we suggest to combine researching phenomena with the generation of personalized feedback as an integral part of a study. In order to do so, we design and implement IT-supported diary studies that provide comprehensive and personalized feedback. In the paper at hand, our contribution is that we (i) identify and describe characteristics of such studies together with the corresponding infrastructure (Section 3), (ii) provide examples and suggestions for individual feedback generation (Section 4) and finally (iii) provide preliminary insights based on several studies we already implemented and executed (Section 5).

A limitation of our research is the still small amount of participants in our studies ($n=74$). In addition, all of our studies were centered on working behaviors and attitudes and their influence on psychological constructs measured by established scales, most notably "human energy". Hence, generalizations to other study topics have to be made with caution so far. However, our results are quite promising since in all studies, we were able to collect required data, analyze the data and provide meaningful feedback, according to our participants.

For the future, we want to develop our assessment study with feedback further into a more intervention-oriented study. In the first step, we will do this by using the feedback as an intervention itself. Thus, while we collected initial perceptions of the

participants on the generated feedback so far, we plan to culminate the optimized conceptual and technical realization focused in this article with a larger study examining specifically the psychological effects of our diary study with feedback on the participants. As a next step, it could be decided, if further interventions might be interesting to add and research. Such interventions might be intended to support behavior change. For example, if a person is regularly low in energy after a meeting, the system could suggest recovery strategies like taking a short walk after meetings, so that this might become a habit little by little.

Our approach may also be helpful in the domain of eCoaching. Since coaching activities often imply to explore and experiment with different interventions and study their effect over a period of time, the impact of different interventions could be tested. Furthermore, an essential part of coaching activities often is to identify contingencies between variables, e.g. to identify how the interplay of certain behaviors affects clinical symptoms or perceived outcomes on target variables. Due to the powerful statistical data analysis capabilities of R, such contingencies could be identified in an automated way and included in the personal feedback. Hence, an avenue of future research would be to develop our design more in the direction of coaching activities.

In summary, there is much opportunity for further exciting developments and we hope that our results will inform and inspire future IT-supported diary studies that include personalized feedback as an integral part of the study.

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REFERENCES

- Albani, C., Blaser, G., Geyer, M., et al. (2005), "Überprüfung der Gütekriterien der deutschen Kurzform des Fragebogens 'Profile of Mood States' (POMS) in einer repräsentativen Bevölkerungsstichprobe, *PPmP: Psychotherapie*

- Psychosomatik Medizinische Psychologie*, Vol. 55 No. 7, pp. 324–330.
- Andreßen, P. and Konradt, U. (2007), “Messung von Selbstführung: Psychometrische Überprüfung der deutschsprachigen Version des Revised Self-Leadership Questionnaire”, *Zeitschrift für Personalpsychologie*, Vol. 6 No. 3, pp. 117–128.
- Arslan, R.C., Reitz, A.K., Driebe, J.C., et al. (2019a), “Routinely randomise the display and order of items to estimate and adjust for biases in subjective reports”.
- Arslan, R.C., Reitz, A.K., Driebe, J.C., et al. (2019b), *Routinely Randomize Potential Sources of Measurement Reactivity to Estimate and Adjust for Biases in Subjective Reports*, Center for Open Science.
- Arslan, R.C., Walther, M.P. and Tata, C.S. (2019c), “formr: A study framework allowing for automated feedback generation and complex longitudinal experience-sampling studies using R”, *Behavior research methods*.
- Balaskas, A., Schueller, S.M., Cox, A.L. and Doherty, G. (2021), “Ecological momentary interventions for mental health: A scoping review”, *PloS one*, Vol. 16 No. 3, e0248152.
- Barber, L.K. and Jenkins, J.S. (2014), “Creating technological boundaries to protect bedtime: examining work-home boundary management, psychological detachment and sleep”, *Stress and Health*, Vol. 30 No. 3, pp. 259–264.
- Bastien, C. (2001), “Validation of the Insomnia Severity Index as an outcome measure for insomnia research”, *Sleep Medicine*, Vol. 2 No. 4, pp. 297–307.
- Biletta, I., Cabrita, J., Eiffe, F., Gerstenberger, B., Parent-Thirion, A., Vargas, O. and Weber, T. (2021), *Working conditions and sustainable work. An analysis using the job quality framework, Eurofound flagship report*, Dublin.
- Burns, M.N., Begale, M., Duffecy, J., Gergle, D., Karr, C.J., Giangrande, E. and Mohr, D.C. (2011), “Harnessing context sensing to develop a mobile intervention for depression”, *Journal of Medical Internet Research*, Vol. 13 No. 3, e55.
- Choe, E.K., Lee, B., Zhu, H., Riche, N.H. and Baur, D. (2017), “Understanding self-reflection. How People Reflect on Personal Data Through Visual Data Exploration”, in *Proceedings of the 11th PervasiveHealth*, ACM, NY, USA, pp. 173–182.
- Coxen, L., van der Vaart, L., van den Broeck, A. and Rothmann, S. (2021), “Basic Psychological Needs in the Work Context: A Systematic Literature Review of Diary Studies”, *Frontiers in Psychology*, Vol. 12, p. 698526.
- Depp, C.A., Ceglowski, J., Wang, V.C., et al. (2015), “Augmenting psychoeducation with a mobile intervention for bipolar disorder: a randomized controlled trial”, *Journal of Affective Disorders*, Vol. 174, pp. 23–30.
- Drucker, P.F. (2005), “Managing Oneself”, *Harvard business review*.
- Fallon, M., Spohrer, K. and Heinzl, A. (2018), “Wearable Devices: A Physiological and Self-regulatory Intervention for Increasing Attention in the Workplace”, in *Neurois retreat 2018, Lecture Notes in Information Systems and Organisation*, Vol. 29, Springer, pp. 229–238.
- Golder, S.A. and Macy, M.W. (2011), “Diurnal and seasonal mood vary with work, sleep, and daylength across diverse cultures”, *Science*, Vol. 333 No. 6051, pp. 1878–1881.
- Grant, A.M. and Parker, S.K. (2009), “7 Redesigning Work Design Theories: The Rise of Relational and Proactive Perspectives”, *Academy of Management Annals*, Vol. 3 No. 1, pp. 317–375.
- Green, F. and McIntosh, S. (2001), “The intensification of work in Europe”, *Labour Economics*, Vol. 8 No. 2, pp. 291–308.
- Heron, K.E. and Smyth, J.M. (2010), “Ecological momentary interventions: incorporating mobile technology into psychosocial and health behaviour treatments”, *British Journal of Health Psychology*, Vol. 15 No. Pt 1, pp. 1–39.
- Holzleitner, I.J., Driebe, J.C., Arslan, R.C., et al. (2017), *No evidence that inbreeding avoidance is up-regulated during the ovulatory phase of the menstrual cycle*, Cold Spring Harbor Laboratory.
- Inceoglu, I., Thomas, G., Chu, C., et al. (2018), “Leadership behavior and employee well-being: An integrated review and a future research agenda”, *The Leadership Quarterly*, Vol. 29 No. 1, pp. 179–202.
- Janssens, K.A.M., Bos, E.H., Rosmalen, J.G.M., Wichers, M.C. and Riese, H. (2018), “A qualitative approach to guide choices for designing a diary study”, *BMC medical research methodology*, Vol. 18 No. 1, p. 140.
- Kazemi, D.M., Borsari, B., Levine, M.J., et al. (2019), “Real-time demonstration of a mHealth app designed to reduce college students hazardous drinking”, *Psychological services*, Vol. 16 No. 2, pp. 255–259.
- Kim, S., Park, Y. and Headrick, L. (2018), “Daily micro-breaks and job performance: General work engagement as a cross-level moderator”, *The Journal of applied psychology*, Vol. 103 No. 7, pp. 772–786.
- Kleinmann, M. and König, C.J. (2018), *Selbst- und Zeitmanagement, Praxis der Personalpsychologie*, Band 38, 1. Auflage, Hogrefe, Göttingen.
- Kroska, E.B., Hoel, S., Victory, A., et al. (2020), “Optimizing an Acceptance and Commitment Therapy Microintervention Via a Mobile App With Two Cohorts: Protocol for Micro-Randomized Trials”, *JMIR research protocols*, Vol. 9 No. 9, e17086.
- Lambusch, F., Weigelt, O., Fellmann, M. and Siestrup, K. (2020), “Application of a Pictorial Scale of Human Energy in Ecological Momentary Assessment Research”, in *Engineering Psychology and Cognitive Ergonomics: Mental Workload, Human Physiology, and Human Energy, Lecture Notes in Computer Science*, Vol. 12186, Springer Nature, pp. 171–189.
- Li, J. and Vogel, D. (2021), “Digital Health Education for Self-Management: A Systematic Literature Review”, *PACIS 2021 Proceedings*.
- Lopper, E., Horstmann, K.T. and Hoppe, A. (2020), “The Approach-Avoidance Job Crafting Scale: Development

- and Validation of a New Measurement”, *Academy of Management Proceedings*, Vol. 2020 No. 1, p. 18656.
- Manz, C.C. and Sims, H.P. (1980), “Self-Management as a Substitute for Leadership: A Social Learning Theory Perspective”, *Academy of Management Review*, Vol. 5 No. 3, pp. 361–367.
- Narciss, S. (2006), *Informatives tutorielles Feedback Entwicklungs-und Evaluationsprinzipien auf der Basis instruktionspsychologischer Erkenntnisse*.
- Ohly, S., Sonnentag, S., Niessen, C. and Zapf, D. (2010), “Diary Studies in Organizational Research”, *Journal of Personnel Psychology*, Vol. 9 No. 2, pp. 79–93.
- Parent-Thirion, A., Biletta, I., Cabrita, J., et al. (2017), *6th European Working Conditions Survey: Overview report, EF, 16/34, 2017 update*, Publications Office of the European Union.
- Pusch, S., Schönbrodt, F.D., Zygar-Hoffmann, C. and Hagemeyer, B. (2020), “Truth and Wishful Thinking: How Interindividual Differences in Communal Motives Manifest in Momentary Partner Perceptions”, *Eur J Pers*, Vol. 34 No. 1, pp. 115–134.
- Quinn, R.W., Spreitzer, G.M. and Lam, C.F. (2012), “Building a Sustainable Model of Human Energy in Organizations: Exploring the Critical Role of Resources”, *Academy of Management Annals*, Vol. 6 No. 1, pp. 337–396.
- Rapp, A. and Cena, F. (2014), “Self-monitoring and Technology: Challenges and Open Issues in Personal Informatics”, in *UAHCI 2014 and HCI*, Vol. 8516, Springer, Cham, pp. 613–622.
- Rentzsch, K., Wiczorek, L.L. and Gerlach, T.M. (2021), “Situation Perception Mediates the Link Between Narcissism and Relationship Satisfaction: Evidence From a Daily Diary Study in Romantic Couples”, *Social Psychological and Personality Science*, 194855062098741.
- Richter, N. and Hunecke, M. (2021), *Are Mindful Days More Sustainable? Mindfulness, Connectedness to Nature, Personal Norm and Pro-environmental Behavior in a Daily Diary Study*, Center for Open Science.
- Schmitt, A., Belschak, F.D. and Den Hartog, D.N. (2017), “Feeling vital after a good night’s sleep: The interplay of energetic resources and self-efficacy for daily proactivity”, *Journal of occupational health psychology*, Vol. 22 No. 4, pp. 443–454.
- Schmitt, A., Zacher, H. and Frese, M. (2012), “The buffering effect of selection, optimization, and compensation strategy use on the relationship between problem solving demands and occupational well-being: a daily diary study”, *Journal of occupational health psychology*, Vol. 17 No. 2, pp. 139–149.
- Shiffman, S., Stone, A.A. and Hufford, M.R. (2008), “Ecological momentary assessment”, *Annual review of clinical psychology*, Vol. 4, pp. 1–32.
- Skakon, J., Nielsen, K., Borg, V. et al. (2010), “Are leaders’ well-being, behaviours and style associated with the affective well-being of their employees? A systematic review of three decades of research”, *Work & Stress*, Vol. 24 No. 2, pp. 107–139.
- Skiena, S.S. (2017), *The data science design manual, Texts in computer science*, Springer, Cham, Switzerland.
- Sonnentag, S. and Kühnel, J. (2016), “Coming back to work in the morning: Psychological detachment and reattachment as predictors of work engagement”, *J. Occup. Health Psychol.*, Vol. 21 No. 4, pp. 379–390.
- Stegmann, S., van Dick, R., Ullrich, J., et al. (2010), “Der Work Design Questionnaire”, *Zeitschrift für Arbeits- und Organisationspsychologie A&O*, Vol. 54 No. 1, pp. 1–28.
- Syrek, C., Bauer-Emmel, C., Antoni, C. and Klusemann, J. (2011), “Entwicklung und Validierung der Trierer Kurzsкала zur Messung von Work-Life Balance”, *Diagnostica*, Vol. 57 No. 3, pp. 134–145.
- Tetrick, L.E. and Winslow, C.J. (2015), “Workplace Stress Management Interventions and Health Promotion”, *Annu. Rev. Organ. Psychol. Organ. Behav.* Vol. 2 No. 1, pp. 583–603.
- van der Krieke, L., Blaauw, F.J., Emerencia, A.C., Schenk, H.M., Slaets, J.P.J., Bos, E.H., Jonge, P. de and Jeronimus, B.F. (2017), “Temporal Dynamics of Health and Well-Being: A Crowdsourcing Approach to Momentary Assessments and Automated Generation of Personalized Feedback”, *Psychosomatic Medicine*, Vol. 79 No. 2, pp. 213–223.
- Vries, L.P. de, Baselmans, B.M.L. and Bartels, M. (2021), “Smartphone-Based Ecological Momentary Assessment of Well-Being: A Systematic Review and Recommendations for Future Studies”, *Journal of Happiness Studies*, Vol. 22 No. 5, pp. 2361–2408.
- Weigelt, O., Gierer, P., Prem, R., Fellmann, M., Lambusch, F., Siestrup, K., Marcus, B., Franke, T., Tsantidis, S., Golla, M., Wyss, C. and Blume, J. (2022), *Time to Recharge Batteries – Development and Validation of a Pictorial Scale of Human Energy*, manuscript submitted for publication.
- Weigelt, O., Siestrup, K. and Prem, R. (2021), “Continuity in transition: Combining recovery and day-of-week perspectives to understand changes in employee energy across the 7-day week”, *Journal of Organizational Behavior*.
- Weigelt, O. and Syrek, C.J. (2017), “Ovsiankina’s Great Relief: How Supplemental Work during the Weekend May Contribute to Recovery in the Face of Unfinished Tasks”, *International Journal of Environmental Research and Public Health*, Vol. 14 No. 12, p. 1606.
- Wyrwich, K.W. and Yu, H. (2011), “Validation of POMS questionnaire in postmenopausal women”, *Quality of Life Research*, Vol. 20 No. 7, pp. 1111–1121.
- Zannella, L., Vahedi, Z. and Want, S. (2020), “What Do Undergraduate Students Learn From Participating in Psychological Research?”, *Teaching of Psychology*, Vol. 47 No. 2, pp. 121–129.